U2505-33-F

Instructional Uses of School Computers

Reports from the 1985 National Survey Issue No. 3, Nov. 1986

Center for Social Organization of Schools The Johns Hopkins University

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What hath the computer wrought? With a million or more computers in use every day in U.S. schools, it seems reasonable to ask what impact computers have had -- on the students, on the teachers, and on the schools themselves.

Potentially, the most important outcomes are improvements in student competencies -- the things they understand and the things that they can do. But measuring the academic consequences of using computers is complicated, and rarely has this been done well, or even done at all. As a survey of teachers, our research could not test students' achievements before and after their computer experiences to measure how they had changed. Nor could we compare students' achievements in classes using computers with those in similar classes providing traditional instruction on the same content. But we could measure teachers' **perceptions** of the effects of the use of computers at their own school and in their own classes.

The validity of these teachers' judgments varies -- some reflecting over-skepticism; others, over-enthusiasm. But by looking carefully at the data (for example, by paying more attention to **relative** perceptions across different outcomes) we can extract strong clues about how learning and instruction in typical classroom settings have been *most* affected by computers and how they have been *least* affected.

This report examines a variety of survey questions that all lead to a common conclusion: As of Spring, 1985, computer-using teachers were excited about the possibilities of using computers and saw significant outcomes occurring mainly in four areas: student motivation, student cooperation and independence, opportunities for high-ability students in programming activities and in other higher-order thinking and writing skills, and oppportunities for low-ability students in mastering basic skills. Nevertheless, the promise of computers was not yet fulfilled for average students, for diagnosing specific instructional needs, for systematic individualization of instruction, or for improving most learning of facts and concepts.

We present two types of survey information in this report. The first several sections present the judgments of principals and primary computer-using teachers ("PCUTs") in more than 2,100 schools in our national sample. They give us their perspective about the impact of computer-use on organizational, social, and academic outcomes at their school in general. The last part of the report presents the opinions of roughly 3,500 computer-using teachers from the same schools about the impact of computers on their own teaching and on students in their own classes.

Note for Readers New to this Series

This is the third of six reports from the Second National Survey of Instructional Uses of School Computers. The results presented are based on questionnaire and interview data from roughly 8,000 principals and computer-using teachers in more than 2,100 computer-using elementary, middle, and high schools, both public and private. These findings represent a statistically representative portrait of computer-using schools in the United States, as of Spring, 1985.

Classroom Social and Instructional Outcomes

Principals and primary computer-using teachers both answered a set of questions about the outcomes of using computers at their school. They indicated whether "as a result of computers," there had been any improvement (or "much" improvement) in such areas as student enthusiasm, peer helping, individualized assignments, diagnoses of learning problems, and learning in regular school subjects by "above-average," "average," and "below-average" students.

These are rather general concepts that reasonable people might disagree about, either because they hold different standards for whether something is "much improved" or because they see these things from the particular perspective of teacher or principal. Not surprisingly, the answers of principals and PCUTs from the same school on most of these items correlated only between .14 and .24, showing substantial differences in judgment. But if we look across all schools of a particular grade span, principals and PCUTs did agree about the outcomes most often experienced and those least often experienced. Table 1 shows the percentages of principals and PCUTs, by school level (elementary, middle, and high school), who indicated that each outcome was "much improved" because of computers.

Across all three school levels, principals and primary computer-using teachers see two areas as most improved: student enthusiasm for the subjects for which they use computers and special opportunities for the academically gifted. In 1983, when we conducted a similar survey, comparable items about enthusiasm and about "above-average" students were also the areas computer-using teachers said were most improved because of computers.

In this survey we asked two separate questions about the "better" students. We asked about "special opportunities for the academically gifted" and about "learning in regular school subjects by above-average students." Although educators reported a great deal of improvement

Table 1: PCUTs' and Principals' Perceptions of Computer Impact: Percent Reporting Outcome "MUCH IMPROVED," by School Level

	K - 6		Middle/Jr.Hi.		High School	
Outcome	PCUT	Prin.	PCUT	Prin.	PCUT	Prin.
Enthusiasm of students for subjects for which computers used.	41%	*	38%	*	40%	*
Special opportunities for the academically gifted.....	28%	40%	36%	42%	29%	43%
Enthusiasm for school in general.....	26%	32%	24%	38%	18%	36%
Special opportunities for the learning disabled.....	24%	28%	26%	30%	15%	19%
Students helping other students with their questions.....	22%	19%	18%	13%	22%	20%
Students working independently without direct supervision.....	18%	21%	16%	17%	23%	23%
Learning in school subjects by below-average students.....	18%	15%	18%	15%	9%	9%
Student assignments tailored to individual needs.....	12%	12%	11%	6%	8%	11%
Learning in school subjects by above-average students.....	11%	16%	6%	9%	4%	11%
Learning in school subjects by average students.....	9%	13%	7%	8%	4%	6%
Diagnoses of students' learning problems or misunderstandings..	5%	4%	6%	5%	2%	6%

* Not asked.

in opportunities for the gifted, they reported very little improvement in academic learning by above-average students, particularly above the elementary grades. This may be because they viewed the "gifted" category as separate from the "above-average" or because above-average middle and high school students use computers mainly for non-traditional academic subjects ("opportunities"?) -- programming, computer literacy, and logic and problem-solving -- rather than for "regular" school subjects like math, science, English, and social studies.

Five other items in Table 1 form a second tier of outcomes seen by principals and PCUTs. Two of these were observed at all levels but more frequently at the elementary and middle school levels ("enthusiasm for school in general" and "special opportunities for learning disabled students"); two were observed somewhat MORE often at the high school level ("students working independently" and "students helping other students with their questions" -- peer helping); and one was reported mainly in elementary and middle schools ("learning in school subjects by below-average students").

As with the items about above-average students, "opportunities" for learning disabled students were reported as more improved than actual learning by below-average students. One explanation is that computers did less to help low-ability students master subject-matter than they contributed to boosting these students' self-esteem -- after all, the students were chosen to use a highly valued piece of school apparatus. Alternatively, "opportunities" may be more easily observed than "learning," and therefore more likely named as having been affected by computers. Still, the perceived impact on learning by low-achieving students reported in this 1985 survey is substantially greater than the impact indicated in our 1983 survey. In that earlier survey, only 7% of the schools reported improved learning outcomes for low-ability students as a result of computers. Even using the more conservative of the items in this 1985 survey, the comparable percentages roughly doubled in two years, particularly at the elementary and middle school levels. None of the other outcome items changed as much in two years.

In our current survey, the outcomes with the least perceived improvement due to computers are individualization of assignments, diagnoses of individual learning difficulties, and learning in regular subjects by average and above-average students. These four areas were at the bottom of the rankings for all three levels -- elementary, middle, and high schools.

Improvements in individualization, attention to diagnoses, and corresponding improvements in academic learning are the kinds of outcomes one might expect if computer-assisted instruction (C.A.I.) approaches were being employed successfully. Computer-assisted instruction does constitute one-third of all computer activity in schools (and even more at the elementary level). But the lack of reported effects on individualization, diagnoses, and academic learning suggests most computer-using teachers and school principals did not see C.A.I. providing a major benefit to students, at least as of 1985.

The lack of impact of C.A.I. may be due to the generally unsystematic way that schools have implemented C.A.I. programs. Few schools have had enough computers to allow half or all of one teacher's class to use programs simultaneously. As of 1985, few schools used a sequence of programs that provided skill practice and instructional dialogue on the full range of objectives covered in a particular course. And few used instructional management systems to direct an individualized sequence of appropriate instruction by diagnosing each student's areas of instructional need.

Differences in Outcomes By Type of School

At all levels, schools with more computers reported more improvement in most outcomes shown in Table 1. For example, among elementary schools, we obtained correlations above .15 between the number of computers at a school and their perceived impact on improving peer helping, increasing use of individualized assignments, and increasing use of diagnoses. Among high schools, the more computers a school had, the more that computers were believed to have improved students' enthusiasm for school in general, increased opportunities for learning disabled students and improved learning by average and above-average students (correlations all between r=.15 and r=.22). Even among high schools with many computers,

however, few schools reported substantial improvement in subject-matter learning because of computers.

Correlations of .15 to .22 may not seem large, but survey measures such as these generally contain a lot of "random error" which generally makes observed correlations substantially lower than their "true" values. Correlations such as these often translate to rather substantial differences in percentage terms. See Table 2 for some examples.

Table 2: Illustrative Relationships between Number of School Computers and Perceived Outcomes of Using Computers*

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Number of Computers Used for Instruction 1 - 4	5 - 14	15 +	Correlation Between Outcome and Number of Computers
Elementary (K-6) Schools:				
Students helping other students with their questions	14%	24%	38%	r=.17
Student assignments tailored to individual needs	6%	16%	25%	r=.18
Diagnoses of students' learning problems or misunderstandings	3%	6%	10%	r=.21
Learning in school subjects by below-average students	15%	20%	32%	r=.13
Special opportunities for the academically gifted	26%	29%	45%	r=.17
High Schools Computers:	1 - 8	9 - 16	15 +	
Enthusiasm for school in general	23%	23%	41%	r=.22
Special opportunities for the learning disabled	17%	19%	33%	r=.19
Learning in school subjects by average students	1%	2%	8%	r=.15
Learning in school subjects by above-average students	1%	6%	10%	r=.18

* Percentages shown are based on "much improved" responses from EITHER principal or PCUT with at least partial agreement from the other.)

Several differences in perceived effects were related to how computer time was allocated among possible uses. Middle and high schools that allocated more computer time to word-processing reported more favorable outcomes generally, and in particular for learning in regular school subjects, for opportunities for learning disabled students, for students working independently of supervision, and for students helping each other. Nine of the twelve school-level correlations between those outcomes and the proportion of computer time allocated to word-processing were r=.15 or greater. (Table 3 shows these relationships in terms of percentages. However, by categorizing the variables for ease of presentation, some distinctions become less clear.)

Table 3: Significant Relationships between Allocation of Computer Time to WORD PROCESSING and Perceived Outcomes of Using Computers*

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for Word Processing (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for Word Proc.
High Schools:			
Learning in school subjects by above-average students	3%	12%	r=.19
Learning in school subjects by average students	1%	13%	r=.20
Special opportunities for the learning disabled	22%	26%	r=.15
Students helping other students with their questions	12%	39%	r=.26
Middle Schools:			
Learning in school subjects by above-average students	8%	12%	r=.16
Learning in school subjects by below-average students	17%	29%	r=.16
Special opportunities for the learning disabled	31%	51%	r=.16
Students helping other students with their questions	12%	33%	r=.15
Students working successfully on their own without supervision	12%	34%	r=.19

* Percentages shown are based on "much improved" responses from EITHER principal or PCUT with at least partial agreement from the other.)

In general, the outcomes that varied the most according to allocations of computer time were perceptions about student peer helping and perceptions about student learning in "regular school subjects." At the elementary school level, peer helping was modestly associated with emphasizing discovery learning and problem-solving activities. (See Table 4.) In fact, peer helping was the only outcome studied that was perceived more frequently in schools emphasizing discovery learning and problem-solving than in other schools at the same level.

The use of computer-assisted instruction, on the other hand, was slightly negatively related to perceived impact on peer helping, at least at the elementary level (r=-.12, see Table 5). However, schools that emphasized C.A.I. did report outcomes that other schools did not. At all levels, they were more likely than other schools to report that computers had improved the use of diagnostic tools and improved academic learning by below-average students (r's between r=.13 and r=.19) and had improved learning by average students at the middle school level (r=.17).

Table 4. Significant Relationships between Allocation of Computer Time to DISCOVERY LEARNING and Perceived Outcomes of Using Computers**

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for Discovery Learning (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for Discovery Lng.
Elementary (K-6) Schools:			
Students helping other students with their questions.....	16%	23%	r=.12
Diagnoses of students' learning problems or misunderstandings.....	31%*	10%*	r=-.18

* percent "much improved" or "improved"
** see note to Table 3.

Allocation of computer time for programming and computer literacy was negatively correlated with perceived learning outcomes at all three school levels. (See Table 6.) This was expected because the questionnaire explicitly asked about learning in "regular school subjects," and most respondents excluded "computers" from what they considered to be regular subjects. Nevertheless, schools that emphasized computer time for programming and computer literacy were also less likely to report improvements in other outcomes, such as peer helping, independence, or opportunities for gifted students. Table 6, for instance, shows that improved peer helping was reported slightly less frequently at middle and high schools emphasizing programming and literacy than at schools where teaching about computers was a small portion of instructional computer time.

Table 5: Significant Relationships between Allocation of Computer Time to COMPUTER-ASSISTED INSTRUCTION and Perceived Outcomes of Using Computers**

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for C.A.I. (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for C.A.I.
Elementary (K-6) Schools:			
Learning in school subjects by below-average students.....	10%	19%	r=.15
Diagnoses of students' learning problems or misunderstandings.....	11%*	32%*	r=.19
Students helping other students with their questions.....	24%	11%	r=-.12
Middle Schools:			
Learning in school subjects by average students.....	6%	12%	r=.17
Learning in school subjects by below-average students.....	14%	28%	r=.13
Diagnoses of students' learning problems or misunderstandings.....	21%*	42%*	r=.18
High Schools:			
Learning in school subjects by below-average students.....	6%	16%	r=.15
Diagnoses of students' learning problems or misunderstandings.....	13%*	32%*	r=.13

* percent "much improved" or "improved"
** see note to Table 3.

Table 6: Illustrative Relationships between Allocation of Computer Time to PROGRAMMING ACTIVITIES and Perceived Outcomes of Using Computers*

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for Programming (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for Programming
Middle Schools:			
Special opportunities for the learning disabled.....	42%	27%	r=-.17
Special opportunities for the academically gifted.....	27%	40%	r=.01
Students helping other students with their questions.....	23%	13%	r=-.02
Students working successfully on their own without supervision.....	21%	16%	r=-.03
High Schools:			
Special opportunities for the learning disabled.....	31%	26%	r=-.13
Special opportunities for the academically gifted.....	26%	22%	r=-.02
Students helping other students with their questions.....	34%	22%	r=-.12
Students working successfully on their own without supervision.....	34%	19%	r=-.16

* see note to Table 3.

Other Outcomes Suggested by Teachers

Besides asking PCUTs and principals to respond to specific ways that computer use might have affected learning and instruction at their school, we also asked PCUTs to write in their own words "another aspect of learning or instruction or one group of students that seems to have been particularly affected by using computers." Teachers answered differently -- some named particular categories of students, others indicated courses and subjects that were most affected, and still others identified skills and traits which they saw students developing through their computer activities. Some answers essentially repeated aspects of instruction about which we had already asked; others were quite different.

Six types of benefits were named most often (listed in order of decreasing frequency): (1) help with logic, reasoning, and problem-solving competence; (2) help for students with particular learning handicaps -- learning disabilities, Chapter I low-income backgrounds, limited-English-speaking minorities; (3) help for other below-average students needing remediation; (4) value for students in gifted and talented programs and other advanced students; (5) value for mathematics subjects and classes; and (6) improvement in self-confidence, a sense of accomplishment, and mastery over computer anxiety. Because the possible answers were so numerous, few respondents (less than 10%) gave any one answer.

Other relatively common answers concerned improvements in discipline, classroom climate, or classroom management and general skills like following directions or listening. Somewhat fewer respondents (again, in order of decreasing frequency) reported benefits for the following types of students, subjects, or skills: drill and reinforcement activities, English or reading, writing quality, social interaction or cooperation, "above-average" students (as distinct from honors or gifted students), initiative or creativity, word processing, computer programming classes, and computer literacy classes.

Also instructive are the kinds of answers which only a few teachers gave: boys, average students, computer buffs, vocational students, foreign language classes, social studies classes, career choices, and factual knowledge.

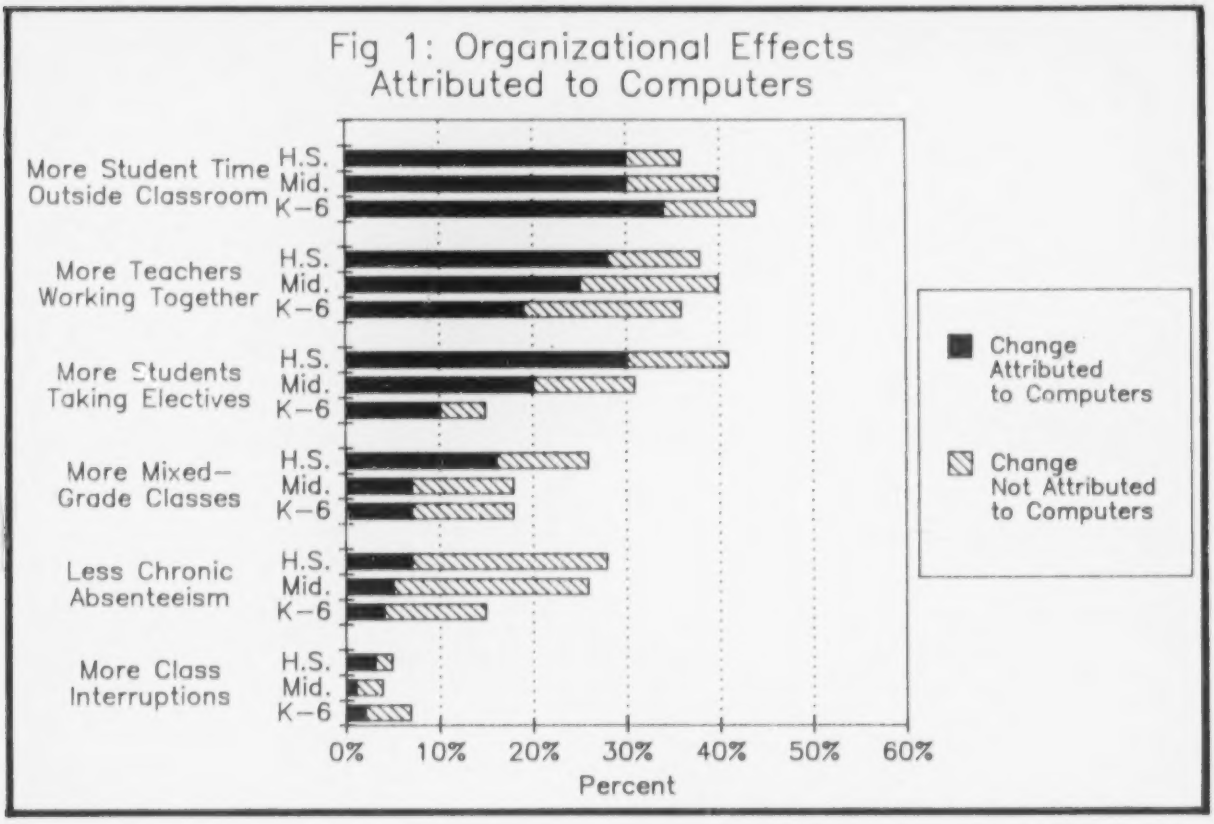
Organizational Outcomes: Principal Reports

Besides affecting students directly, computers might be changing how school instruction is organized. To assess this, we asked school principals with at least two years tenure at their current school about several aspects of school organization: the proportion of time that students spent in non-classroom instructional settings, such as labs and resource rooms; the assignment of students from different grade levels to the same classes; the provision of elective classes; teacher collaboration across grade levels or departments; absenteeism; and the frequency of classroom interruptions. The principals were asked how these aspects of school organization had changed in the past three years and whether the use of computers was related to the changes that they saw.

At all three levels, elementary, middle, and high school, only a minority of principals believed that these aspects of school organization had changed in their building. For three of the six areas, however, a majority of principals who DID report changes believed that computers were related to the change.

The organizational change most often experienced and the one most often attributed to computers was an increase in the time that students spent "away from regular classrooms -- in libraries, labs, resource rooms." At the elementary level, 44% of principals reported an increase in non-classroom activities, and, of that 44%, 78% believed that computers were related to this increase. Thus, 34% (i.e., .44 x .78) of elementary schools reported increased out-of-classroom activity because of computers. (See Figure 1.) Nearly the same proportion of middle schools and high schools also reported this effect.

Two other effects of computers were reported by a substantial number of principals at computer-using middle and high schools: an increased number of electives and an increased frequency of teachers from different departments working together on joint projects. Again, although a minority of principals (30 to 40 percent) reported these changes, most who did felt that computers were at least partly responsible (63% to 75%, depending on school level and the item). A smaller proportion of



elementary school principals reported these two changes, but most of those who did attributed the changes to computers.

Fewer than 10% of principals at computer-using schools believed that computers affected the other three aspects of organization asked about. Computers were seen as increasing the frequency of mixed-grade classes in 16% of high schools, but only 7% below that level. Only 5% of the principals saw computers as a factor in decreasing absenteeism, and only a few believed them to be responsible for increasing classroom interruptions.

Other School-Level Changes

In our questions to computer-using **teachers**, we asked how their school's use of computers had changed over the past year. We asked about changes in the amount of use (days of non-use and incidence of waiting lines or sign-up sheets), teacher involvement (how often teachers borrowed computers for use at home), and recreational use (students playing arcade games and copying commercial software). Their answers extend our understanding of the increased use of computers suggested by the statistics on time-of-use, described in issue 1 of this newsletter series.

Nearly half of the schools reported that their computers sat idle for fewer days than they had a year earlier, and nearly 40% reported that there were more days on which students either stood in line or signed up in advance to use school computers. (See Table 7.) Few schools reported changes in the opposite direction. Additionally, one-third of the schools reported increased borrowing of computers by teachers for use at home.

In contrast, recreational use of school computers seems, on balance, to have decreased. Schools were more likely to indicate a decline in students' arcade game playing than to indicate an increase. And, below the high school level, most schools said that students did not use school computers to copy commercial software. Still, with the increasing activity at school computers, it was not surprising that more schools suggested that copying was increasing at their school than said it was decreasing. (See Table 7.)

Table 7: Perceived Changes in Certain Aspects of Computer Use

	Changes Compared to One Year Earlier			
	More Often	No Change	Less Often	(Never Any)*
Days when computer is not used.....	5%	17%	47%	31%
Queuing (waiting lines or sign-up sheets).....	38%	30%	11%	21%
Teachers borrowing computer for home instruction or use	31%	32%	6%	32%
Arcade game playing.....	13%	24%	21%	42%
Students copying commercial software.....	12%	17%	5%	66%
K-6 Elementary schools.	6%	10%	2%	82%
Middle schools.....	21	18	8	53
High schools.....	19	32	12	37

* "Never Any" of that type of use of computers.

A belief that computers were responsible for improved student learning and a better academic climate was most prevalent at schools reporting increased computer activity -- where there was more queuing for computers, less idle time, and more frequent borrowing of school computers by teachers. The student outcomes most related to increased computer activity were student enthusiasm (at all school levels), and peer helping, independent work, and individualized assignments (in the elementary grades). For example, of the elementary schools that reported having a declining number of days where computers were idle (or no idle days at all), 38% indicated that computers had caused "much more" enthusiasm for school subjects. But only 12% of elementary schools where idle days were stable or increasing reported that computers had had that kind of an effect.

Middle schools that reported increased queuing for computers also perceived computers to have a stronger effect on peer cooperation, independent student activity, and individualized assignments than those reporting declines in queuing. For example, 22% of middle schools that reported increased queuing for computers said that there was a much greater incidence of students working without direct supervision (as a result of computers). Only 7% of middle schools that said there was never any queuing for computers indicated such an effect. High schools where an increasing number of teachers borrowed computers were more likely to report better outcomes associated with low-performing students, and high schools increasingly beset with lines and sign-up sheets for computer use reported better learning outcomes for all types of students.

Of course, the causal forces work in both directions. For example, student enthusiasm probably causes less idle computer time and more queuing, but increased computer use may also generate more enthusiasm as well. Similar issues of directionality remain for the other associations discussed above.

Recreational use of computers had only a limited impact on the student outcomes measured. Below the high school level, schools with an increasing or stable use of computers for playing arcade games reported outcomes no different from schools that said that arcade game activity was declining or non-existent. At the high school level, there were a few small relationships. The largest was that high schools reporting increased game playing were less likely than other schools to indicate that computers had resulted in "more learning" by average students (24% vs. 43%). Increased student copying of computer programs was not associated with any of the outcomes examined, except for a slight relationship at the high school level between increased copying and computers having less of an impact on learning by average students.

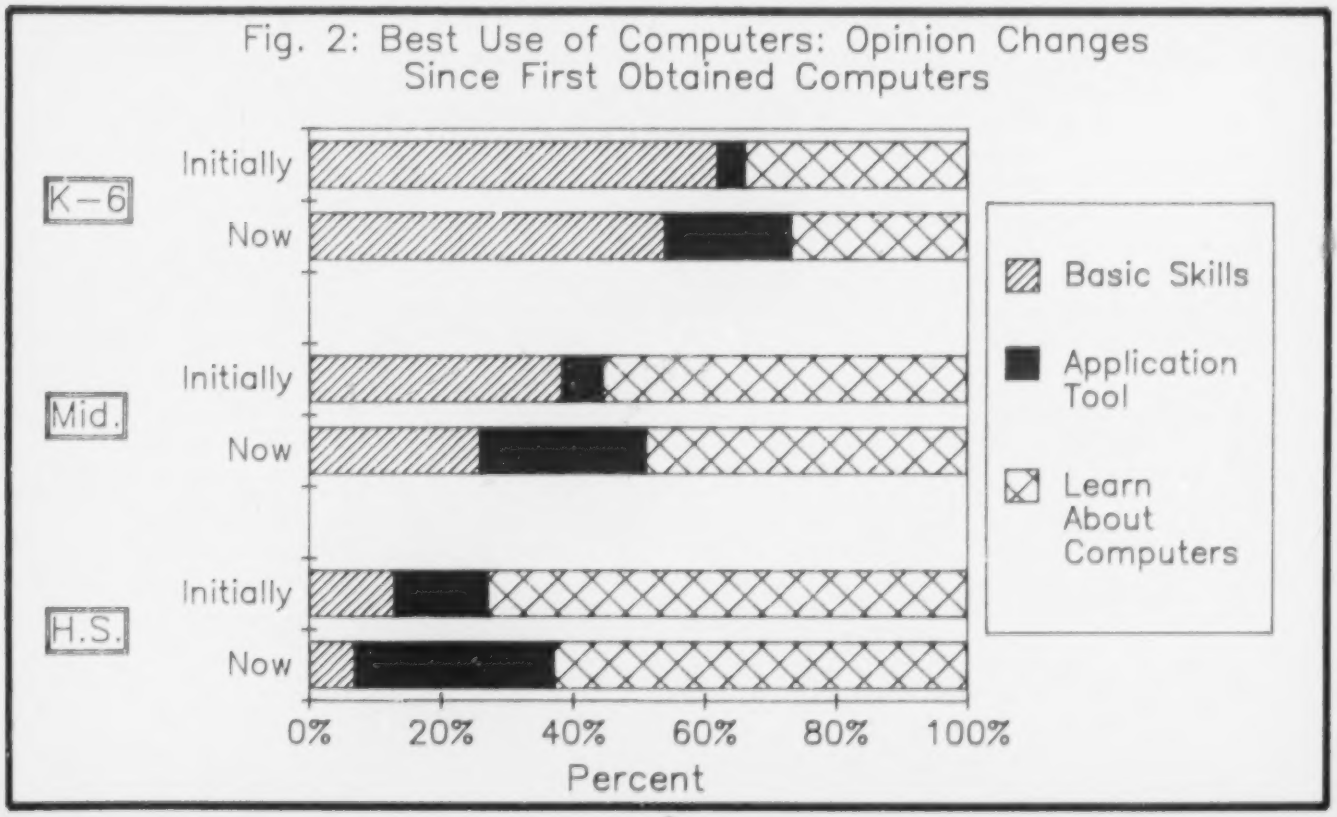
One-half of the schools that had used computers for two years or more reported an increase in the number of students who could "touch type," and one-third of the schools with computers for two years reported offering typing or keyboarding instruction to students at lower grade levels than previously. A similar proportion of schools at all levels -- elementary, middle, and high school -- reported these increases.

Basic Skills Teaching, Object of Instruction, or Applications Tool?

One goal of this survey was to see whether, over time, schools were changing their views about the best way to use computers. We asked the primary computer-using teachers which one of three major uses of computers seemed best at the time their school got its first computer and which one seemed best now (in 1985). The three approaches were (1) using computers as a method of improving students' basic skills in mathematics or language, (2) using computers as a resource to learn more about computers, and (3) using computers as a tool for students to accomplish an academic task -- such as in writing, analyzing data, or solving problems. We analyzed these questions only for schools that were into at least their third year of having computers and where the primary computer-using teacher was at least familiar with the school at the time it began getting computers. Figure 2 summarizes the results of this analysis.

Elementary and secondary schools had quite different views about the best way to use computers. Not surprisingly, the differences paralleled differences in how computers were actually being used at the two levels. A majority of K-6 school PCUTs with two or more years of computer experience believed that the best use of computers at their level was applying them to students' mastery of basic reading and math skills. Middle and high school PCUTs believed that the best use of computers at their level was mainly for students to develop computer-related skills such as programming. "Learning about computers" was the choice of one-half of the PCUTs at middle schools and nearly two-thirds of the PCUTs at high schools with two years of computer experience.

However, when we look at how the responses to the question about "current best use" differ from those given for "use thought best at first," we see similar changes in opinion



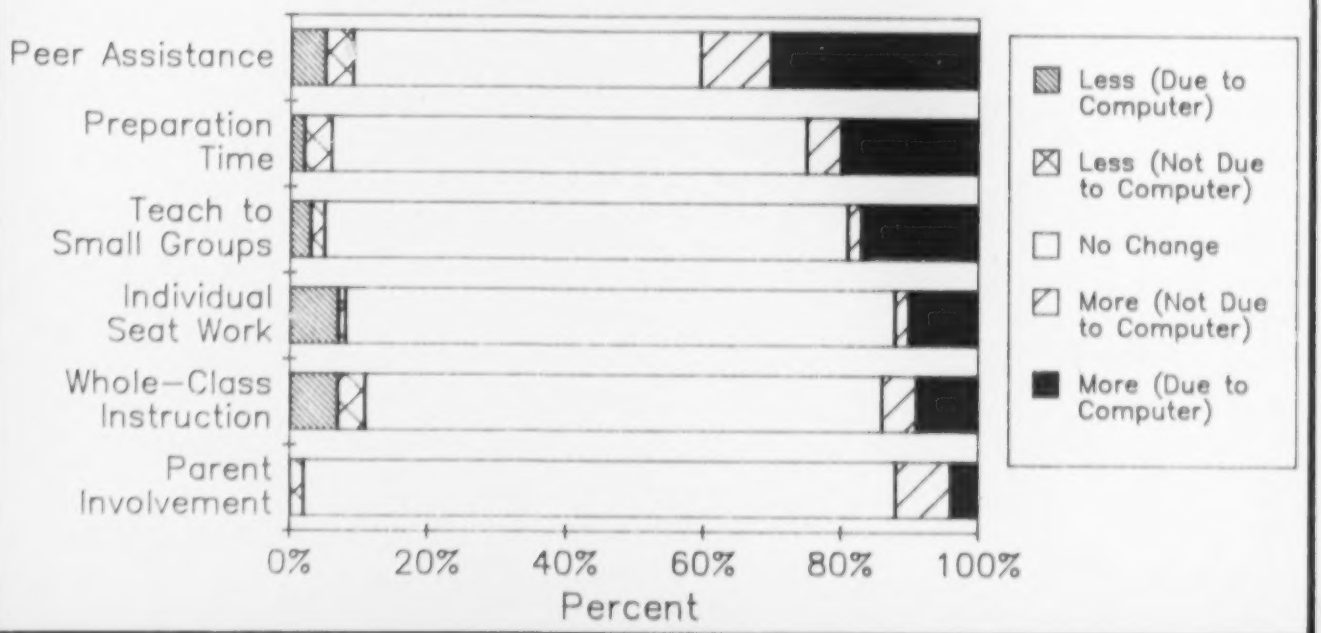
occurring in both elementary and secondary schools. An increasing proportion of elementary, middle, and high school PCUTs were coming to believe that the best way to use computers at their school was as a tool to help students accomplish concrete tasks -- tasks in writing, problem-solving, data analysis, and perhaps other areas. A similar change in emphasis was occurring during this period in the professional literature on educational computing. Favoring "tool uses" was still a minority viewpoint among educators in 1985, but it was becoming more significant. It would be instructive to learn whether it has become the dominant preference among PCUTs today.

Changes in Teaching Methods

The results discussed so far are generalizations made by school principals and primary computer-using teachers about the computer's impact on the school as a whole. The remaining survey results derive from individual computer-using teachers about how computers have affected their own teaching practice. We asked teachers to tell us about changes in their teaching methods since they began using computers -- changes that might be attributable to their use of computers. We named six possible effects: changes in (1) how frequently they divided their class into groups for instruction and other activities, (2) how often they assigned individual seatwork, (3) how frequently they used whole-class lecture or discussion methods, (4) how often students were instructed to tutor or help one another, (5) how much they worked evenings and weekends preparing to teach, and (6) how often the teachers talked with students' parents (an expected "non-effect" that served as a baseline comparison). We asked teachers to discuss each of these possible changes for one particular class or subject they taught -- the first class or subject taught during the day for which computers were sometimes used. We excluded teachers who wrote about subjects that could not be adequately taught without computers such as "computer literacy" or "computer programming" courses.

The vast majority of teachers reported that their style of organizing classroom instruction and how much time they put into class preparation had not changed since they began using computers. Still, some changes attributed to computers were reported much more often than others. Figure 3 shows the proportion of computer-using teachers of grade 6-8 classes who indicated an increase, a decrease, or no change, in each aspect of instruction for the sampled

Fig. 3: Changes in Teaching Practices Since Began Using Computers for Subject -- Grade 6 to 8 Classrooms



subject. The proportion attributing such changes to computers is indicated by darker patterns than those indicating the changes were not computer-related. Although Figure 3 displays data for the middle grades only, the changes in instructional practice most often attributed to computers were about the same at all levels.

High school teachers reported more changes than middle-school teachers, and middle-school teachers more than elementary school teachers. Also, the higher the grade-level taught, the more likely that a reported change was attributed to "computers." For example, at the elementary school level, 59% of the reports of changed instructional practice were attributed to computers, compared to 70% at the middle school level and 79% at the high school level.

The largest reported impact of computers on instructional practices was on mutual helping among students. Roughly 40% of computer-using teachers indicated that they increasingly used peer-tutoring and helping -- somewhat more at higher grades and somewhat less below grade six. Of the computer-using teachers who reported increased use of peer helping, more than three-quarters said that their use of computers was at least partly responsible.

Increases in class preparation time were reported by 25% of the middle grade computer-using teachers and by 37% of the high school teachers. Well over 80% of the teachers reporting increased preparation time said that computers were responsible.

There were fewer changes reported for whole-class instruction, instruction in small groups, and seatwork than for peer-helping and preparation time. Averaging for these three types of classroom organization, changes were reported by 28% of high school computer-using teachers, 23% of teachers of the middle grades and 18% of K-5 teachers. The most common change was an increase in grouping -- dividing the class into work groups and teaching one group while another used available computers and others did seatwork or group work. Also, increases in seatwork assignments were reported somewhat more often than decreases, particularly at the high school level. Changes in grouping and seatwork practices were attributed to computers by 80% of the teachers reporting such changes, but only a slight majority of those indicating a change in whole-class instruction also attributed this to computers.

As expected, the least change reported was for "talking with parents." Only 10% reported increases in this area (and 2%, deceases), and fewer than one-third of those reporting changes attributed them to the use of computers.

Teachers of some types of classes reported more changes in teaching practice than others did. Below the high school level, computers caused increased preparation time and peer helping practices mainly in classes with high ability students. (See Table 8.) For example, among elementary grade computer-using classes, 26% of the teachers of low- and mixed-ability classes reported increased peer-tutoring and peer-helping practices, but nearly twice as many, 48%, of the teachers of high-ability K-5 classes reported these effects. Comparable results obtained at the middle grades. Similarly, one-fifth of middle school teachers of low- and mixed-ability classes and even fewer elementary teachers of low- and mixed-ability classes said that the time they devoted to class preparation had increased because of computers, but roughly one-third of high-ability class teachers in these grades reported spending more time on class preparation because of computers.

Table 8: Changes in Classroom Teaching Practices by Class Ability Level*

	K-5 Grade Classes			6-8 Grade Classes		
Changes in Practice	High Ability	Average & Mixed	Low Ability	High Ability	Average & Mixed	Low Ability
Increased Use of Peer Tutoring, Helping	48%	26%	26%	45%	32%	21%
Increased Evening, Weekend Preparation	30%	10%	15%	33%	19%	22%
Increased Within-Class Grouping	11%	8%	19%	11%	16%	19%
Increased Use of Seatwork	9%	8%	8%	10%	10%	12%
Decreased Whole-Class Instruction	1%	4%	9%	9%	3%	15%

* Excludes classes about computers ("literacy" and "programming") that would not have been taught WITHOUT computers.

Some computer-related changes in classroom organizational structure were more often reported by elementary and middle grade teachers of low-ability classes than by teachers of mixed- or high-ability classes. Twice as many teachers of low-ability classes in these grades reported increased use of grouping for

instruction and decreased whole-class instruction than did teachers of mixed- or high-ability classes. Still, compared to the effects of computers on peer-group and preparation time, relatively few teachers of any ability levels reported these organizational effects.

High school teachers reported a very different pattern of effects. Teachers of high- and low-ability classes were less likely to see an impact of computers on their teaching practice than were teachers of average- and mixed-ability classes. This is probably related to the subjects for which classes of different ability levels used computers. High school math and science teachers primarily used computers with high-ability math and science classes and low-ability math classes, and math and science teachers were the least likely to report changes in teaching practice because of computers. Average- and mixed-ability computer-using classes are exemplified by business and English classes, where teachers were the most likely to report that using computers had changed their teaching practices.

Half of the high school business computer-using teachers said that computers had increased their practice of asking students to help one another, but only 20% of high school computer-using math and science teachers said this. (See Table 9.) Similarly, business teachers were more than twice as likely as math or science teachers to indicate that computers had increased their use of grouping for instruction (24% vs. 11%), increased their frequency of assigning seatwork (28% vs. 9%), or decreased their use of whole-class instruction (21% vs. 7%). Almost as many computer-using high school English teachers reported that computers had affected their teaching practice as did business-education teachers. For example, 46% said that computers had increased their use of peer tutoring in English classes, and 26% said that they assigned more individual seatwork because of computers.

The effects of these teaching practices on student learning are not easy to predict. Most educators would agree that seatwork has rapidly declining marginal value for individual students, but it does contribute to more efficient classroom management. Instructing students in small groups may have particular value in heterogeneous classes or where subject-matter learning is highly cumulative, but its overall effectiveness depends on how well activities are organized for times when the teacher's attention is elsewhere. At its worst, group activity can degenerate into recreational time and makes classroom management more difficult. Whole-class instruction is most effective in teaching less complex skills and concepts, especially to homogeneous classes, where a common instructional pace is functional for most students. Even the value of having students tutor and help one another may depend upon the way roles, tasks, and incentives are organized and the subject-matter and student body involved. There is no guarantee that slower or less motivated students will learn more from group activity than from teacher-centered whole-class instruction. We cannot simply assume that, because many teachers report

Table 9: Changes in High School Teaching Practices by Subject*

Changes in Practice	Business Classes	English Classes	Science Classes	Math Classes	Other Classes
Increased Use of Peer Tutoring, Helping	50%	46%	21%	19%	34%
Increased Evening, Weekend Preparation	45%	24%	24%	25%	36%
Increased Within-Class Grouping	24%	22%	10%	12%	18%
Increased Use of Seatwork	28%	26%	8%	10%	15%
Decreased Whole-Class Instruction	21%	22%	5%	8%	5%

* Excludes classes about computers ("literacy" and "programming") that would not have been taught WITHOUT computers.

increased peer helping as a result of computer use, resulting student mastery is uniformly better.

In any event, computers seem to have had limited effects on the organization of classroom instruction to date. Increased peer helping is about the only way that computers have affected major classroom teaching processes. Otherwise, computers have not substantially affected how teachers teach their material or run their classes. The one thing they have done, of course, is to make teachers work harder and longer preparing for their classes. Whether this is simply a short-term consequence of changing classroom activity patterns, or whether it is a long-term concomitant, we cannot say.

What Did Teachers Report That Students Learned "Better, Faster, or More Thoroughly" Because of Computers?

Besides asking computer-using teachers about how computers affected their teaching practice in one particular class, we also asked for their opinion about how computers might have affected student learning in that class. The question was put in an "open-ended" format so that teachers were free to name anything they felt that students had "learned better, faster, or more thoroughly because of their use of computers in this subject?"

The teachers' responses generally reflected the subject for which they used computers. In mathematics, a majority of teachers named "math facts" as a way that students' learning had been affected by their use of computers. Most often, specific improvements that they mentioned related to computational speed or automaticity. Far fewer teachers indicated improvements in comprehending or applying mathematics concepts.

The responses of K-5 English and reading teachers were about equally split among reading comprehension, vocabulary, grammar, and spelling; fewer teachers at this level mentioned improvements in writing or editing skills. However, writing improvements were among the most important outcomes perceived by English teachers of older students. In the middle grades, writing improvements were mentioned as often as improvements in grammatical usage (21% of the teachers) and more often than spelling, reading comprehension, or vocabulary. Among high school English teachers using computers, fully 69% indicated that students had improved their writing, editing or proofreading skill by using computers -- a greater consensus than for any other "effect" for any subject at any grade level. In addition, more business education teachers indicated improvements in student writing than indicated any other learning effect (21%). Overall, 19% of all high school computer-using teachers suggested that improved writing was an important outcome of their use of computers, a higher percentage than those naming any other outcome. Of course, it should be recalled that teachers of classes ABOUT computers (programming and computer literacy classes) did not answer this question, because it was part of the series of questions about how teaching practice in the subject had changed since the teacher began using computers.

Improvements in math, spelling, reading, and vocabulary were noted generally more often by teachers of low-ability classes than by teachers of mixed- or high-ability classes. (The percentages for those four subjects combined were 66% of low-ability classes, 43% of mixed-, and 26% of high-ability classes.) More teachers of high-ability classes than low- or mixed-ability classes volunteered that students' logic, critical thinking, and problem-solving skills had improved through the use of computers (20% vs. 8% and 11% respectively). Also, keyboarding and typing skills were named as having been improved more often in high-ability classes than in low- and mixed-ability classes (12% vs. 4%).

Overall, the answers to this question about "things learned better, faster, or more thoroughly" reinforces the idea that computers have been more effective in high- and low-ability classes than in average or mixed-ability classes. Teachers of mixed-ability classes were more likely to simply answer the question of what things have students learned "better, faster, or more thoroughly" by saying "none." One-third of teachers of mixed- or average-ability classes said "none" compared to 16% of teachers of low-ability classes and 20% of teachers of high-ability classes. Actually, we were surprised that this many computer-using teachers gave the "none" response. Nearly any response the teachers wrote in would have been coded as indicating some improvement due to computers. The fact that more than one-quarter of the teachers wrote "none" suggests that,